

XP-000964714

21

P.D.	1368	8
P.	143-150	

Trochanteric Fractures of the Femur

Treatment with a Strong Nail and Early Weight-bearing

S. L. WEISSMAN, M.D., AND R. SALAMA, M.B., B.CH.

The nail-plates used for internal fixation of trochanteric fractures can maintain the fragments in the reduced position while affording greater mobility of the patient in bed, in an armchair or a wheelchair. However, most nail-plates cannot support body weight in general use and even supported ambulation has to be postponed for a variable period of time, depending on the stability of the reduction. In spite of all precautions, some of these nails are apt to bend or break.

The possibility of providing fixation strong enough to withstand the stresses encountered during the postoperative period and to allow early weight bearing prompted us to develop a stronger device. After careful study, a device designed by the junior author (R.S.) was adopted.⁶ It has been used in 200 cases during the period from December 1963 to December 1968. This report is an account of our experience with this new device in the first 100 cases.

EVOLUTION OF THE MODIFIED NAIL-PLATE

A modified nail-plate with a "strut" added to the conventional nail-plate design was devised. A nail-plate angle of 125° was decided upon, because at this angle the tip of the strut will be nearest to the tip of the

nail and will penetrate farthest beyond the fracture line, thus affording maximum support and leaving only a short portion of the nail unsupported proximally. The distance from the nail-plate angle to both ends of the strut is 5.2 cm. In this position, the strut will be as near as possible to the medial cortex of the femur and the nail will still be applicable to all cases.

The new device consists of a stainless steel nail-plate with an angle of 125° , shown in Fig. 1: near the distal end of the plate is the strut holder (A) that has the 2-fold purpose of fixing the strut (B) to the plate and directing it toward the strut block (C) in the nail. The nail is 4-flanged with sharp cutting tips and rounded edges. On its inferior surface toward the distal end is the strut block. The strut is a smooth, round, 7-mm-thick rod with its length so calculated as not to protrude more than .5 cm at its distal end. It is pointed at one end to fit the hole in the strut block. The other end is square and can be screwed to the strut holder by using a special T-wrench (Fig. 6).

In the first models the strut consisted of a long screw. In its present form it is stronger and easier to introduce. The strut holder and the protruding end of the strut have also been made smaller in the later models (Fig. 2). Three nail lengths have been used: 8, 8.5 and 9 cm. The plates are 4, 5 or 6 inches long; the one most commonly-used is the 4-inch plate.

From the Department of Orthopaedic Surgery and Traumatology, Tel-Aviv University Medical School, Ichilov Hospital, Tel-Aviv, Israel.

The nail-plate was tested in a hydraulic stress machine. It was screwed vertically to a heavy base with the plate projecting above the superior margin of the base by 1 inch to stimulate the stress incurred when the device is used to fix a subtrochanteric fracture. The load at first yield and the maximum load were the same. The latest models of the nail-plate withstood loads of more than 290 kg (640 pounds) before they began to give way. Increasing the load bent the strut and plate without breaking them. We have had no opportunity to investigate experimentally the strength of the proximal end of the femur after nailing with the new device.

PATHOMECHANICS

Foster² has stated 3 factors in weight-bearing using the nail-plate that show how the conditions in the body are more favorable for stress tolerance than the experimental conditions. (1) The effective leverage on the nail-

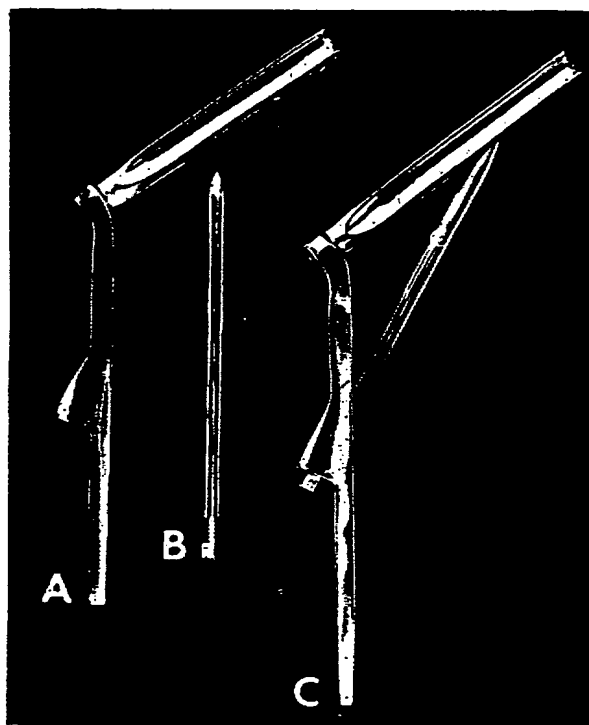


FIG. 1. Latest model of the new nail-plate: A, nail-plate, with strut holder in middle of plate; B, strut; C, complete nail-plate.

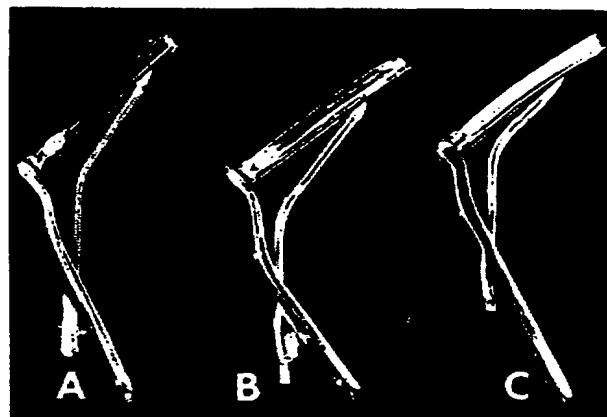


FIG. 2. Stress tolerance and failure pattern of the different models: A, 150 kg (330 pounds); B, 294 kg (646 pounds); C, 291 kg (640 pounds). In the first model (A) the strut consisted of a long screw. The strut holder and the protruding end of the strut have been made smaller in the second and third models (B and C).

plate angle is reduced since the force on the femoral head is transmitted not only to the tip of the nail, but also to the part embedded in the proximal fragment, which is also supported in its middle by the strut in the new nail (Figs. 7 and 8). (2) The direction of the forces acting on the femoral head is not vertical, but inclines $10-15^\circ$ medial to the perpendicular.⁴ (3) The plate is not vertical, since it is screwed to the femoral shaft which inclines downwards and medially at an angle of $9-15^\circ$ to the vertical.⁸

These factors are illustrated in Figure 3. They have the same effect on the stresses at the strut-plate angle as if that angle were increased by the sum of angles (2) and (3) above. If these angles are given average values of 12° each, the strut will be placed at an angle of more than 170° , i.e. almost parallel to the line of force. The bending moment on the strut-plate junction at such an angle is only about 5 per cent of the maximum moment.² The forces acting on the strut will be essentially compressive and the resistance of the strut to such forces is great.

BEST AVAILABLE COPY

ment is also reduced since the lever arm AC' is shorter than AC (Fig. 4).

In the new nail-plate the forces will pass first through a system composed of the proximal part of the nail, the strut and the distal part of the plate (Fig. 4 II, in black) and it is only if this system is overcome that the forces will act on the rest of the nail-plate.

Pauwels estimated that during the stance phase of walking, an average person exerts a static force of 385 pounds on the stationary hip. This weight can be reduced to 200 pounds by pushing down on a stick with the opposite hand with a force of 20 pounds.¹ Since the resistance of the nail-plate in experimental conditions less favorable than those in the body is more than 600 pounds, it was estimated that there was a wide-enough safety margin to allow weight-bearing within a few days after internal fixation with the new nail.

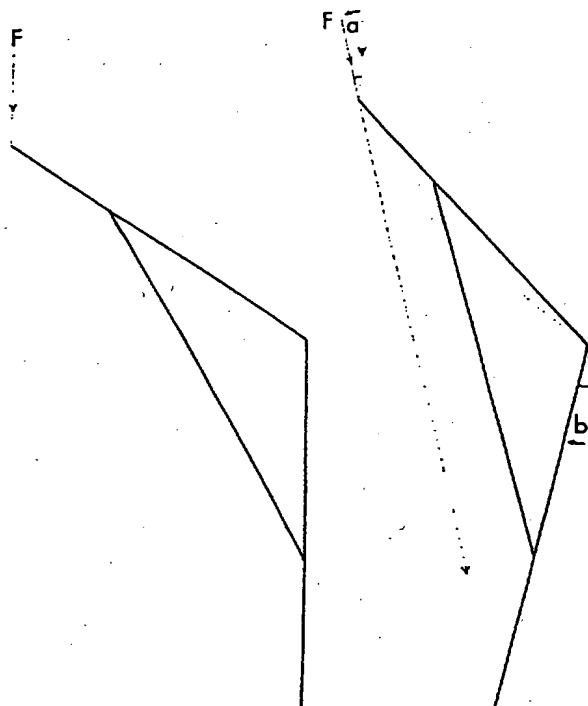


FIG. 3. F—direction of forces acting on the femoral head. a—angle of inclination of the resultant of the forces acting on the femoral head.⁴ b—angle of inclination of the femoral shaft.⁸

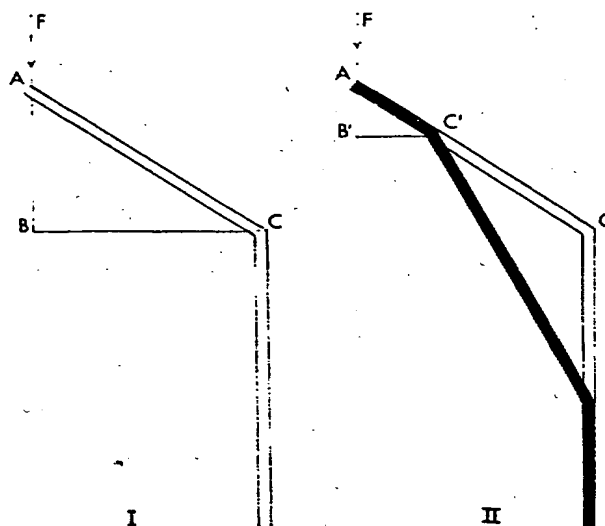


FIG. 4. The bending moment at the nail-strut angle is about 3 times less than that at the nail-plate angle of an ordinary nail-plate, since the lever arm AC' (I) is about one-third of AC (II). In the new nail-plate the forces will pass first through the system composed of the proximal parts of the nail, the strut and the distal part of the plate (II, in black). Only if this system is overcome will the forces act on the rest of the nail-plate (in white).

Moreover, Sarmiento⁷ proved experimentally that proper placement of the nail and anatomic reduction of the fracture double the function strength of the unit. Therefore, when these conditions are met there is a wide safety margin.

MATERIALS AND METHODS

This report concerns the results in 100 consecutive fractures in patients ranging in age from 20 to 98 years. Sixty patients were over 70 years old and only 5 were under the age of 50. Thirty-one were men and 69 were women. Forty-five fractures were on the right side and 55 were on the left side. Eighty-one fractures were intertrochanteric, 11 subtrochanteric and 8 were basal.

As a rule, all patients admitted with a trochanteric fracture were operated on unless they had not been walking prior to sustaining the fracture or there was a major contraindication to operation, such as congestive heart failure or myocardial infarction. Of the 100 patients 63 were operated on within the first 24 hours and

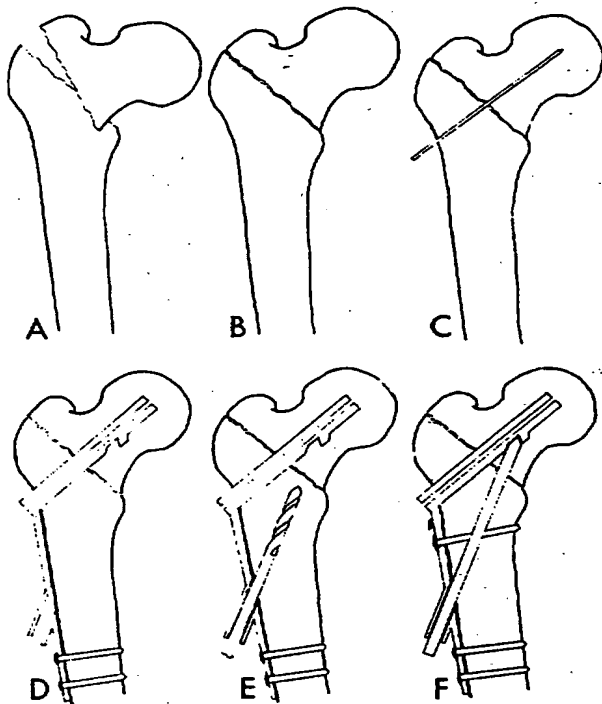


FIG. 5 A-F. Operative technic. After reduction and introduction of the nail (A-C), the plate is fitted to the femoral shaft by introducing the lower horizontal screws converging in the coronal plane and the fracture is impacted (D). A hole is then drilled in the lateral cortex with a 7-mm drill passed through the strut holder (E) and the strut is hammered in and screwed with the T-wrench (F).

22 were operated on within the first 48 hours. The remainder underwent surgery within a few days; the last operation took place after seven days.

No deaths occurred in the operating room. There were 12 deaths, which were caused by: congestive heart failure (3), pneumonia (3), myocardial infarction (2), pulmonary embolism (1), cerebro-vascular hemorrhage (1), renal failure (1) and perforated peptic ulcer (1).

The average duration of hospitalization in the remaining 80 patients was 19 days. Before the results could be evaluated, 5 more patients died out of hospital of: cerebral hemorrhage (2), intestinal hemorrhage (1), myocardial infarction (1) and unknown (1). The average age of the seventeen patients who had died was 77.5 years. Three patients did not report at followup and could not be traced.

OPERATIVE TECHNIC

The operative procedure differs very little from the usual nailing of trochanteric fractures (Fig. 5). After reduction of the fracture and introduction of the nail, the plate is fixed to the femoral shaft by introducing the lower horizontal screws converging in the coronal plane. Reduction should be as near to anatomic as possible. The nail is centrally placed and should be long enough to reach a point about 1 cm from the articular surface. Traction is released and the fracture is impacted by applying firm hammer strokes to the introducer, which is reattached to the nail. Impaction, which must be done in every case, can be demonstrated radiologically. Impaction should be performed at this stage because once the strut is introduced impaction might be difficult.

A hole for the strut is then drilled in the lateral cortex with a 7-mm drill passed through the strut holder. In younger patients where the bone is harder it is usually easier to start with a thinner (5 mm) drill first. The drill should be driven deep enough to prepare a passage through the strong medial trabeculae. We have been using an additional instrument (Fig. 6 D). The drill is passed through this tube, which is screwed to the screw holder. The tube protects the soft tissues while drilling the hole in the lateral cortex and serves as an additional guide for the drill during the procedure. The pointed probe (Fig. 6 C) is next introduced, as a control, until it meets the under surface of the nail. The strut is then gently hammered in and screwed home with the T-wrench until it meets the nail and fits into the hole in the strut block. Now the strut is fixed at both ends. The position is again checked radiographically.

To prevent the upper horizontal screw from being in the way of the strut it is introduced only after the strut is already in place.

POSTOPERATIVE MANAGEMENT

The patient is able to sit in an armchair within the first 24 to 48 hours. He is then allowed to stand on both feet and take a few steps with the help of a light portable walker (after the fifth day) if his general condition permits and the wound appears to be healing well. Full weight-bearing is encouraged from the start. As soon as he feels sufficiently secure, the walking distances are progressively increased and he is readied for discharge. After 3 to 4 weeks usually a cane was substituted and used until there was bone union. Most patients were advised to continue the use of a cane till they felt secure.

The use of crutches in elderly patients was avoided because it is usually very difficult to teach them to walk with crutches. The walker is safer and easier to use. A light chair was also a very satisfactory substitute to the walker, especially for home use.

The patients were usually discharged from hospital 2 to 3 weeks after surgery. They were re-examined 1 month after discharge and then at intervals of 1 month to 6 weeks until there was solid bone union.

Followup ranged from 4 to 40 months.

CASE REPORTS

Case 1. A.E., an 82-year-old woman, sustained a trochanteric fracture of the right hip with a subtrochanteric component following a fall in the street (Fig. 7 A, B). She was operated on the next day (Fig. 7 C, D) and partial weight-bearing in a walker was started on the tenth day after surgery. The patient progressed rapidly and she was discharged on the twenty-second day after surgery, walking with a light portable walker. On reporting for followup 3 weeks later, she was walking freely using one

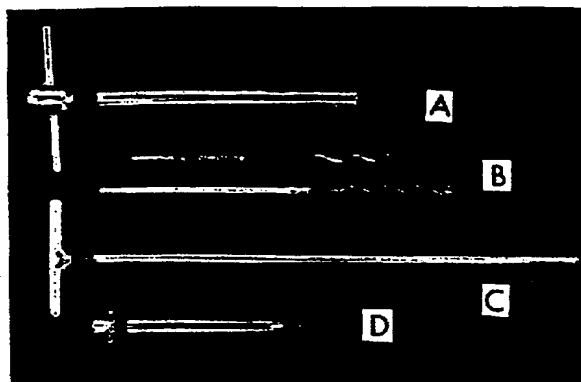


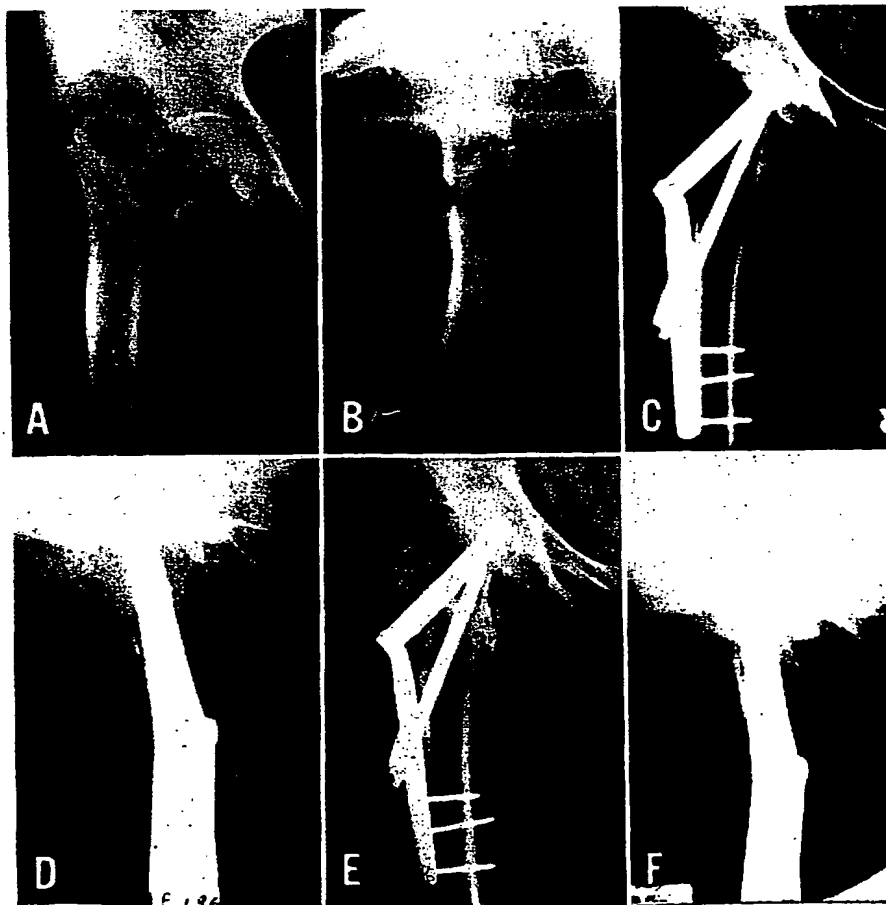
FIG. 6 A-D. Necessary accessories: (A) T-wrench; (B) 7-mm drill bit; (C) probe; (D) tube screwed to the screw-holder. This tube is useful in protecting the soft tissues while drilling the hole in the lateral cortex and also serves as an additional guide for the drill during the procedure.

cane as a support. Radiographs made 10 weeks after the operation showed bony union of the fracture (Fig. 7 E, F). The patient was walk-

FIG. 7 A-F. Case 1. A-B, Severely-displaced trochanteric fracture of the right hip with a subtrochanteric component in an 82-year-old woman.

C-D, Anteroposterior and axial-postoperative radiographs showing good reduction and position of the nail.

E-F, Anteroposterior and axial radiographs 10 weeks after operation showing solid bone union. The patient was walking without any support at home. She was using a cane outdoors mainly because she had been instructed to use it.



BEST AVAILABLE COPY

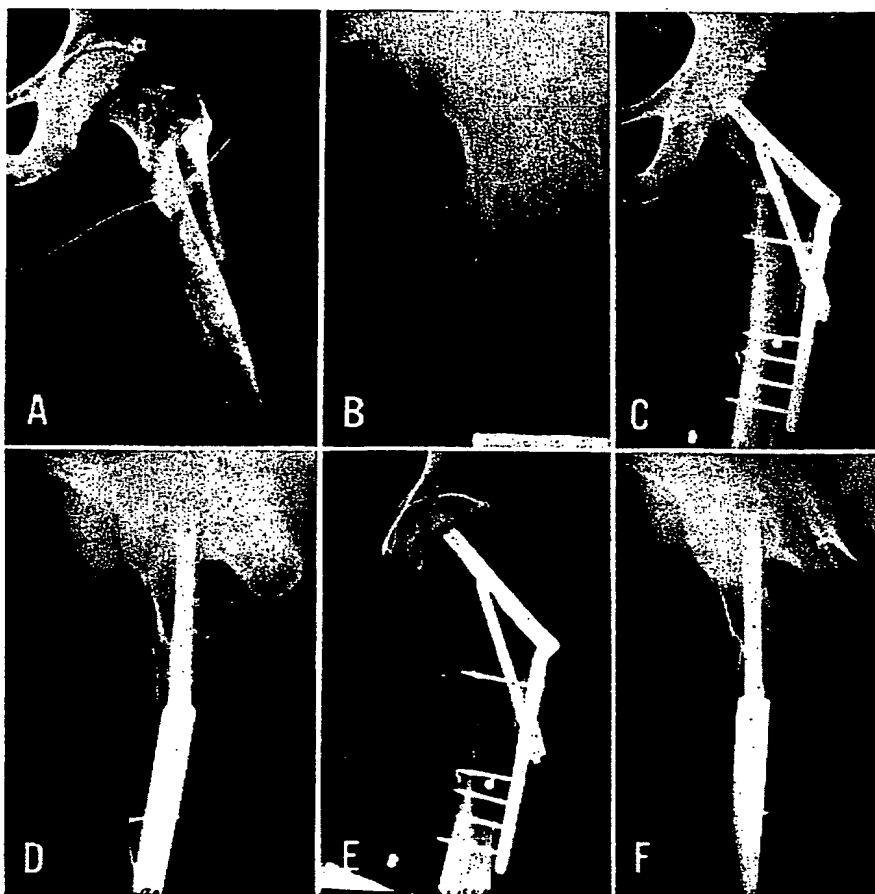


FIG. 8 A-F. Case 2. A-B, Intertrochanteric and subtrochanteric fractures of the left hip in a 58-year-old man. The intertrochanteric fracture is undisplaced.

C-D, Anteroposterior and lateral radiographs made 5 weeks after operation showing good reduction and proper placement of the nail. An additional anteroposterior screw was used to fix a large posterior fragment. There is evidence of early bone union and there have been no changes in the position of the fracture in spite of early weight bearing.

E-F, Anteroposterior and lateral radiographs made 9 months after operation showing solid bone union. The patient was using one cane only at that time.

ing without any support at home. She was using a cane outdoors mainly because she had been instructed to use it indefinitely. She had no pain and was completely self-sufficient.

Case 2. V.K., a 58-year-old man, sustained intertrochanteric and subtrochanteric fractures of the left hip following a fall from a height (Fig. 8 A, B). He was operated on the next day. A nail with a 6-inch plate was used and an additional anteroposterior screw was used to fix a large posterior fragment. He began partial weight bearing 10 days after surgery. When discharged 16 days after the operation, he was walking with 2 crutches. Three weeks later there was no change in the position of the fracture and there was evidence of early union (Fig. 8 C, D). He was allowed to use only one crutch and gradually change to one cane after 2 more weeks. Nine weeks after surgery there was radiologic evidence of solid bone union (Fig. 8 E, F) and the patient was walking with one cane without any pain.

RESULTS

Of the 80 patients in whom the results could be evaluated, 70 had a good result without any change in the original reduction of the fracture, advancement of the nail or penetration of the joint space. About half the patients (39) were already walking well with 1 cane about the sixth week after surgery; some of them were even refusing the use of the cane, especially indoors. Seventeen started to use 1 cane only after the first followup examination at 6 weeks. The remaining 14 lacked self-confidence although they had no pain on full weight bearing. They had to be persuaded to discard the walker at 10 to 12 weeks. They were, however, ambulatory and self-sufficient. In all these patients, radiologic evidence of bone

BEST AVAILABLE COPY

union was present after periods ranging from 2 to 4 months.

There were 10 patients with poor results. Two patients over eighty years old refused to walk and became bedridden after they had been discharged from hospital. There was no evidence of failure of fixation or displacement of the fracture in these 2 patients and no evidence of motion at the fracture site. Three patients had a deep infection; this necessitated removal of the nail and resection of the hip in 2, whereas the third recovered and had a final good result. In one patient, the nail reached the center of the neck. It was too short to extend into the hard bone of the femoral head, with consequent loss of position and union in slight varus of about 10°. In one patient the nail was badly placed and cut out of the neck before walking was attempted. In the 3 other patients the screws broke and the plate was slightly displaced away from the femoral shaft. The breakage of the screws was recognized when routine radiographs were made in 2 of the patients. These two continued to walk with support and the fractures united in slight varus of about 10 to 15°. The third patient was an irrational 65-year-old man who refused any support after operation. Ten days after discharge he jumped from a slight height and felt a sudden, acute pain in his hip. He continued to walk and reported back the next day because of persistence of the pain. Although the screws were replaced by thicker 5/32-inch screws with a good eventual result, the case was considered one of the failures. Poor reduction was thought to be the cause of complication in these 3 cases. Varus was only slight because of the fixation provided by the strut. For the last 2 years, 5/32-inch screws have been used instead of 9/64-inch screws and this complication has not occurred since.

A few thin patients complained of slight tenderness at the site of the strut holder in the earlier cases. After the strut holder and the protruding distal end of the strut were

made smaller (Fig. 4), none of the patients complained of tenderness.

No evidence of bending or breaking of the nail was observed in any case. There has not been a single case of failure of the thick (5/32-inch) screws, in more than 100 cases.

A striking observation was the minimal amount of pain experienced by the patients even on walking shortly after operation. This may be due to the strength and stability of fixation. The patients were usually easily convinced to discard the walker and use canes only as a support. This, together with the short period of immobilization, accounts for the easy and rapid rehabilitation. Most of the patients were ready for discharge 2 weeks after operation.

DISCUSSION

Holt³ has demonstrated that most of the nail-plates currently used for internal fixation of trochanteric fractures are inadequate for early weight bearing. He advocated early weight bearing using a strong nail-plate of his own design. Sarmiento,⁷ using a high-angle I-beam nail also allowed early weight bearing, restricting its use, however, to stable fractures. The use of a strong nail-plate of new design in this series is further evidence that patients suffering from trochanteric fractures can begin to walk with very little support shortly after surgery without jeopardizing the results, even in unstable and subtrochanteric fractures.

Although achieved by the use of a different device, our results are much similar to those of Holt's series, which also included unstable and subtrochanteric fractures. There seems to be ample evidence that, provided the internal fixation device is strong enough, weight bearing in all trochanteric fractures is possible from the earliest moment.

The operative procedure is no more difficult than the usual nailing of trochanteric fracture, and little extra time is needed for the introduction of the strut.

The nail is as easily inserted as a conven-

tional nail-plate; it is easier to insert than the high-angle nails. Furthermore, the presence of the strut at an angle of 152° to the shaft and flush against the inferior cortex of the neck simulate the high-angle nails as advocated by Massie⁵ and Sarmiento.⁷

The strut and nail form a wedge that tends to prevent medial displacement of the lower fragment and penetration of the nail into the joint in severely comminuted fractures or subtrochanteric fractures with reversed obliquity of the fracture line.

SUMMARY

The results from the use of a new, strong nail-plate in more than 100 trochanteric fractures are presented to affirm the point of view that a strong nail permits early weight bearing and earlier rehabilitation of the patient.

REFERENCES

1. Blount, W. P.: Don't throw away the cane, *J. Bone Joint Surg.* 38A:695, 1956.
2. Foster, Y. C.: Trochanteric fractures of the femur treated by the vitallium McLaughlin nail and plate, *J. Bone Joint Surg.* 40B:684, 1958.
3. Holt, E. P., Jr.: Hip fractures in the trochanteric region: Treatment with a strong nail and early weight-bearing, *J. Bone Joint Surg.* 45A:687, 1963.
4. Inman, V. T.: Functional aspects of the abductor muscles of the hip, *Amer. J. Surg. N. S.* 73:150, 1957.
5. Massie, W. K.: Extracapsular fractures of the hip treated by impaction using a sliding nail-plate fixation, *Clin. Orthop.* 22:180, 1962.
6. Salama, R.: Modified nail-plate for trochanteric fracture of the femur, *Lancet.* 1:893, 1965.
7. Sarmiento, A.: Intertrochanteric fractures of the femur, *J. Bone Joint Surg.* 45A:706, 1963.
8. Walmsley, T.: The vertical axes of the femur and their relations: A contribution to the study of the erect position, *J. Anat.* 67:284, 1933.